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FINAL REPORT

on

POLAR CAP PATCHES: INVESTIGATION OF FORMATION MECHANISMS AND SOURCE PLASMA

by

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29 November, 2005

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Introduction

We have carried out analysis and interpretation of data from several EISCAT optical campaigns. September 5-8, 2005 we carried out a campaign at EISCAT Svalbard Radar (ESR). The report is divided in two parts. In Part I the main scientific results are listed up in the form of abstract of papers submitted for publication in peer review scientific journals. Part II is reporting a statistical survey of flow transients in the cusp based on all the ESR "patch campaign" data at hand.

PART I : Scientific results submitted for publication

Paper 1 submitted to Gephysical Research Letters, 2005:

Direct observations of injection-events of subauroral-plasma into the Polar Cap

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Abstract

While polar cap ionospheric patches have been studied for over two decades, there remains no general agreement to which of many proposed patch-production mechanisms are important or dominate. An experiment was designed and implemented to search for transient events redirecting subauroral ionospheric plasma from its subauroral flow to transient injection into the polar cap, as would occur for the Lockwood and Carlson (1992) mechanism of patch creation. An earlier experiment provided compelling evidence of this mechanism acting within the cusp, but only "smoking gun" evidence regarding the source-reservoir for the plasma injected into the polar cap. The work here, for the first time, "tracks the bullet" continuously from subauroral latitudes before the event fires, through the cusp and into the polar cap. We conclude that this mechanism must be a dominant patch generation mechanism and highlight that poleward-moving-form research has direct application to polar cap patch generation by magnetopause reconnection.

Paper 2 submitted to Annales Geophysicae, 2005:

On the Origin of Polar Cap Patches

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Abstract

Although polar cap ionospheric patches were discovered over two decades ago, there is still not agreement as to the dominant mechanism(s) by which they are created. Here we examine in detail many of the observable ionospheric manifestations of the events attendant to their creation, ordering a wide array of radar, radio, and optical observations within the framework and context of one particular patch-production mechanism proposed by Lockwood and Carlson (1992). This mechanism identifies many geophysical parameters and boundaries, each of which must show very specific responses to patch production events, and whose absence can disprove the presence of the mechanism. The combined EISCAT Svalbard and Tromsø (ESR and VHF) radars are unique in their ability to subject this mechanism to a critical test. The transient changes in parameter values, motion of their sharp boundaries, and the relative spatial and temporal timing of same, as predicted by the mechanism under examination, are found to match those observed, for: optical flashes and arcs, plasma densities, velocities, electron and ion gas temperatures, and additional backscatter and scintillation effects. We conclude that: this is a dominant mechanism for polar cap patch generation; the framework of the mechanism helps order and predict much observed phenomenology; it establishes a basis for application of a large body of "PMF" research to patch physics and phenomenology; and it support the broader physical basis on which the proposed mechanism was based.

Paper 4 submitted to Annales Geophysicae, 2005:

The adiaroic boundary and the low-latitude boundary layer under small clock angle IMF

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Abstract
The adiaroic boundary of the polar cap under conditions of Bz>0 and small clock angle is identified in the ion drift measured by the EISCAT Svalbard Radar. Coincident particle flux observations by the NOAA-12 satellite reveal energetic (>30 keV) electrons characteristic of closed field lines near the boundary, together with a population of softer precipitating magnetosheath particles. This particle energy-distribution was distinct from that of the central plasma sheet (CPS) observed at lower latitudes. The plasma near the adiaroic boundary is interpreted as being low-latitude boundary layer (LLBL) plasma under northward IMF. It is suggested that this region occurred on polar-cap magnetic field lines that were opened at an earlier time when IMF Bz<0, but where some had subsequently closed under Bz>0 by lobe reconnection in both northern and southern hemispheres.

Paper 5 submitted to Annales Geophysicae, 2005:

Observations of a new Category of Plasma Patches at Sub-Auroral Latitudes

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Abstract
Polar cap patches are islands of high density ionospheric plasma, surrounded by plasma of density at a factor of two less dense. It was early recognized that midlatitude ionospheric plasma produced by solar EUV provided a viable reservoir of source plasma for polar cap patches, by convection into the polar cap. However, models at the same time showed smoothly varying polar convection patterns to produce a continuous tongue of ionization, not distinct islands, by now a long standing tenet of the field. Here we present EISCAT data over Svalbard that counters this tenet.The observations track ionospheric plasma from the sub-auroral region through the polar cap entry region, demonstrating no need for further segmentation to be observable as strong polar cap patches. The data show a series of three successive intense ($\sim 10^{12}$ m^{-3}) large (~300 km x 700 km) patches that have been preformed at sub-auroral latitudes. Their high density, large scale, and associated intense level of consequent scintillation make them a clearly important class of patches, which require both recognition and further study by the scientific community if we are to understand the fundamental science and practical consequences of polar patches.

PART II : A statistical survey of flow transients

1. Introduction

We have operated ESR in various fast scan modes for several campaigns from 16.01.2001 – 15.12.2002. The fast scan operation was originally designed to map formation and movement of polar cap patches near cusp. Figure 1 from Carlson et al. [*Geophysical Research Letters,* 2002] illustrates tracking of a north-west moving electron density patch by 60-degree azimuth sweeps. The radar sweeps are designed to move fast enough through the F region ionosphere to revisit cusp events several times as they propagate through the field-of-view at typical speeds of 0.5-1 kms^{-1}. This wind-shield wiper mode has enabled us to observe in detail the local flow disturbance of single flux transfer events Oksavik et al.[Geophysical Research Letters, 2004]; first suggested by Southwood [1987]. Narrow channels (50-100 km) of fast flow seem to be a characteristic feature of the auroral ionosphereUnder the current grant we are carrying out a systematic search through our entire data base for temporary flow events. It turns out that flow events occurred at 34% of 877 day scans 29% of 503 night scans. For further work on this data material we will be particularly interested to see how local flow disturbance are related to formation of electron density patches in the cusp.

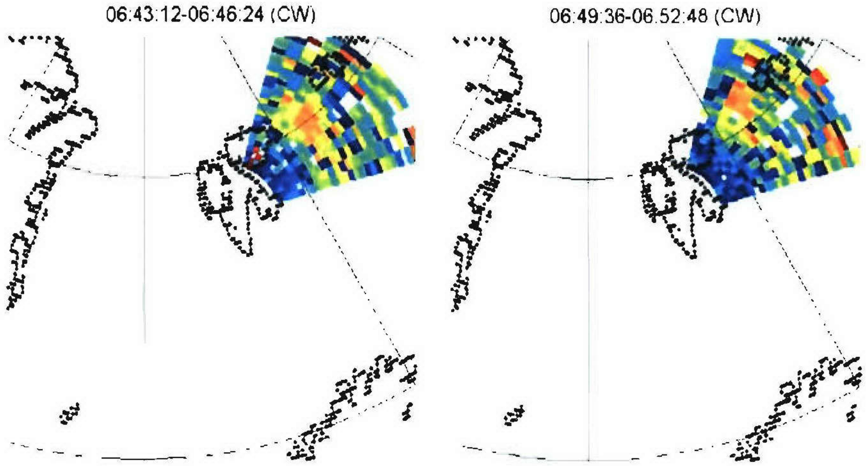

Figure 1: Mapping of an electron density patch propagating northwest in the fan-shaped field of view on January 18, 2001.

2. Data analysis

The data set contains 1380 scans by the ESR in the time period from 16.01.2001 – 15.12.2002. In order to get an overview of the dynamics in the data, the primary plasma parameters (v_i, T_i, n_e, T_e) were plotted in a 5 x 4 can matrix plot format as illustrated in Figure 2.

The dates and times of day when the radar was operated are shown in Table 1. For each day (first column), the time of the day when radar data is available is shown in the second column, and any larger data gaps for the actual day are shown in the third column. Furthermore, the duration of one azimuth scan in seconds (fourth column) and the number of events registered during the time period (fifth column) are shown.

By manual inspection of the v_i data, events were narrow channels were visible in the data where identified and listed in Table 2. Each event is classified by a number of parameters explained in Section 2.1 below.

Furthermore, the polarity of IMF B_z and B_y were determined for each event and it was checked whether there was a signature corresponding to the event in the ESR n_e data and/or allsky camera images from Ny-Ålesund (listed in Table 3)

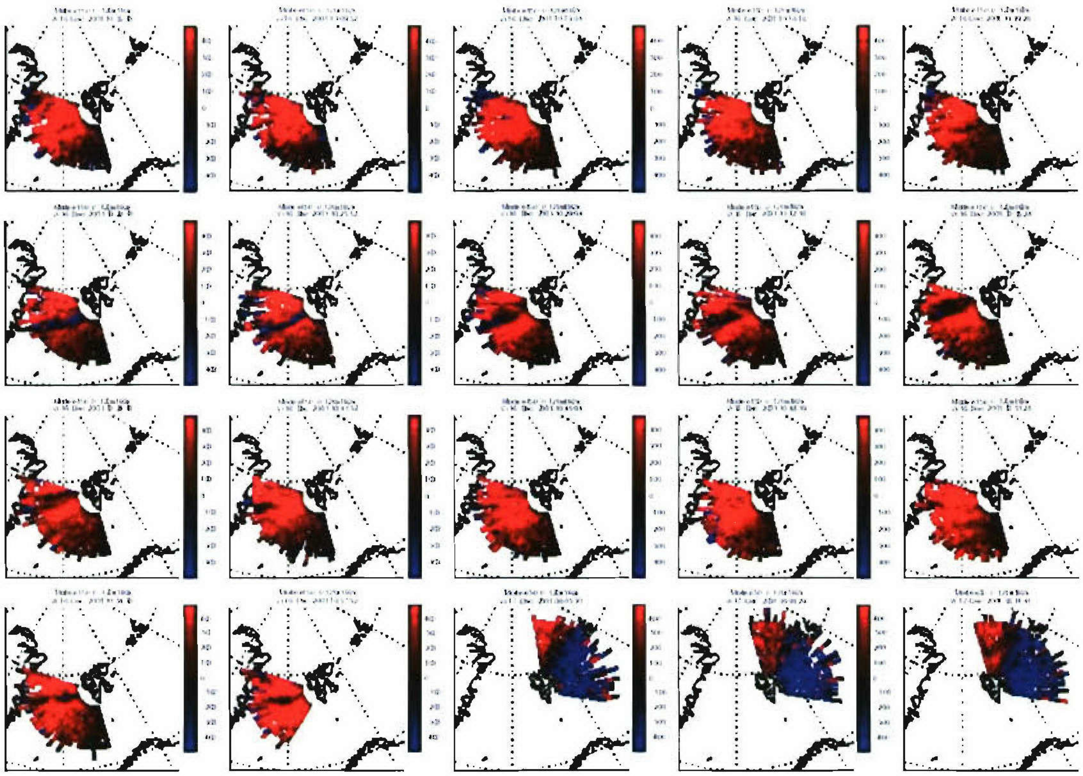

Figure 2: Example of the scan matrix plot format used to plot the ESR data

2.1 Description of the columns in Table 2:

images:

This number states how many scans the event is visible on.

Quadrant:

Indicates which quadrant the event is located in (see Figure 2). The flow event - narrow blue line- is located in the third quadrant.

Dir. of ion flow: (Direction of ion flow)

The colors in a scan indicate the direction of the ion movement relative to the radar, red being away from the radar and blue towards the radar. The direction of flow indicated in the table is relative to the geographic poles rather than to the magnetic poles, for example the direction of flow of the event (blue narrow line) in figure 2 would be north-east.

Quality:

Ranges an event's overall quality: "*poor*", "*ok*" and "*good*". The purpose of the colors used in the table is to make it easier to identify the events. The quality of an event was determined visually and consists of several factors: how good the event emerges from the background (velocity difference between the event itself and the background), how good

the data quality is throughout the event and whether how speckled the data around the event is.

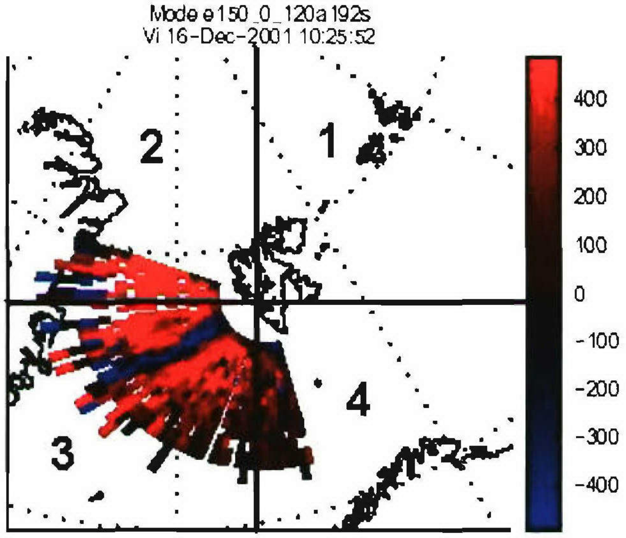

Figure 3: Quadrant arrangement

Class:

"c.c." – convection channel (the event in the third quadrant in Figure 3 would be a typical convection channel)

"spot" – spot in the vi data (see example in the right panel in Figure 4)

Convection reversals (as shown in the left panel of Figure 4) are not considered and listed here.

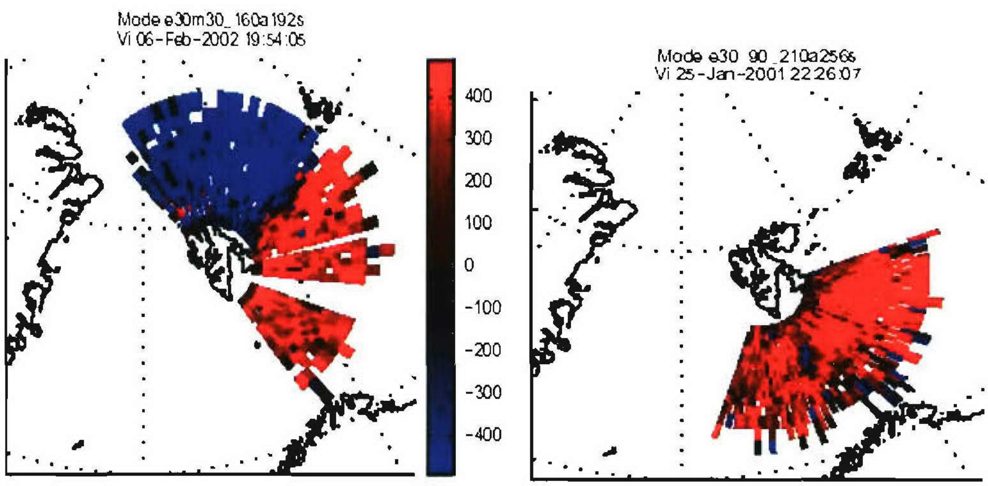

Figure 4: Example of a convection reversal (left) and a velocity spot (right)

Wideness:
Ranges an event in terms of how wide it is in terms of extension. Expressions used: "medio", "narrow".
The event shown in Figure 3 would typically be a narrow event.

Background:
Describes the background of the v_i data. Terms used are:
"*Uniform*", "*ok*", "a *little diffuse*" *and* "*diffuse*"

Comment:
Gives a short comment describing the event, like for example on which scans the event is best visible or whether the ion velocity in the convection channel is rather low.

IMF B_z / B_y:
Polarity of the interplanetary magnetic fields z and y-component measured with the ACE satellite during the event (see Section 2.2 for time delay calculation). Can either be "*positive*", "*negative*" or "*fluctuates*" (if IMF B_z changes sign during an event in such a way that it is not possible to determine whether it is positive or negative).

Ne sig.: (N_e signature)
States if there is a signature (like for instance an electron density patch) corresponding to the event visible in the n_e data. "*Gap*" indicates that the convection channel is associated with a decreased electron density, "*enhanced*" indicates that the electron density corresponding to the event is enhanced compared to the background. "*Precipitation*" indicates that there is electron precipitation associated with the event.

2.2 Time delay calculation:

In order to determine during which IMF conditions an event took place it is necessary to account for the propagation time of the solar wind from the ACE satellite to the ionosphere. For this purpose, a matlab program (IMFshifter.m) has been written.

Since this programs only purpose is to evaluate the sign of the IMF for the events, no sofisticated program is needed. The time delay has been calculated by two methods: 1) Brute force calculating the advection time along the Sun-Earth axis, and 2) a formula by Lockwood et al. [1989] given as:

$$T_{tot} = \frac{1}{v_{sw}}\left[X_s - 1.3X_m - \left(Y_s \cdot \frac{B_x}{B_y}\right) + 2.6X_m\right]$$

X_s, Y_s: Satellite positions in GSE coordinates, [km]

B_x, B_y: IMF components, [nT]

V_{sw}: solar wind speed, [km/s]

X_m: magnetopause coordinate calculated by Rodgers [1998] formula:

$$X_m = 107.4\left(N_{sw} \cdot V_{sw}^2\right)^{-\frac{1}{6}}$$

N_{sw} = hydrogen density in the solar wind, [#/cc]

3. Summary:

The data set contains scan periods during the early morning hours and evening/night hours (Table 1). For a statistical analysis of the events, day and nighttime was treated separately. The daytime set consists of almost twice as many scans as the nighttime set.

3.1. Daytime observations:

In the whole data set consisting of a total of 1380 scans, 877 scans are daytime scans. The daytime data set contains a total of 95 events spread over 300 scans, implying that that roughly 34% of the scans contain events.

47 of the events where rated "good" (49.5%), 29 "ok" (30.5%), 19 "poor" (20%).

3 of the 95 events (3.2%) were spots, 92 (96.8%) were convection channels.

Of all 95 events, 61.1% had north east flow (58), 9.5% north-west flow (9), 14.7% south east flow (14) and 14.7% south west flow (14).

Only 14 events (14.7%) occurred during a period with negative IMF By.

Of all daytime scans[1)], the radar scanned 46.3% (495 scans) in the first quadrant, 32.5% (348 scans) in the second, 19.5% (208 scans) in the third and in 1.7 % (18 scans) the fourth.

53.6% (51 events) of the events where located in the first quadrant, 20% (19 events) in the second, 27.4% (26 events) in the third and 0% (0 event) in the fourth.

Events occur 28% of the time scanned in the first quadrant (51 events spanning 139 scans), 16.6% in the second (19 events, 58 scans), 49.5% in the third (26 events, 103 scans) and 0% in the fourth (0 events).

To get an idea of the average duration of an event, the first step was to calculate the average number of images an event was visible on for each day (since the scan mode could change for different days). The average number of images was then multiplied with the number of seconds used for one scan.
Then, having calculated the average duration of an event for one day, all the days where added together and an average over the whole daytime set found.

The average duration of an event in the daytime data set found by this method was 8min 38 sec.

[1)] if one scan scanned all quadrants, it is calculated as one scan for each quadrant→ total amount of scans now 1069 since some scans count several times.

3.2. Nighttime observations:
In total, 503 of the scans are nighttime scans. The whole nighttime data set contains 32 events spread over 110 scans, implying that that roughly 29% of the scans contain events.

21 events where rated "good" (65.6%), 10 "ok" (31.3%), 1 "poor" (3.1%).

7 of the 32 events (21.9%) were spots, 25 (78.1%) were convection channels.

Of all 32 events, 31.2% had north east flow (10), 34.4% north-west flow (11), 9.4% south east flow (3) and 25% south west flow (8).

8 events (25%) occurred during a period with negative IMF By.

Of all nighttime scans[2)], the radar scanned 29.1% (383 scans) in the first quadrant, 32.9% (432 scans) in the second, 5.1% (68 scans) in the third and in 32.9% (432 scans) the fourth.

37.5% (12 events) of the events where located in the first quadrant, 9.4% (3 events) in the second, 18.7% (6 events) in the third and 34.4% (11 event) in the fourth.

Events occur 10.7% in the first quadrant (12 events spanning 41 scans), 2.3% in the second (3 events, 10 scans), 19.11% in the third (6 events, 13 scans) and 10.6% in the fourth (11 events, 46 scans).

The calculation of the average duration of a nighttime event was carried out the same way as for the daytime data, the only difference being that the scan mode not necessarily was constant throughout one day, so that periods with constant scan mode had to be considered.

The average duration of a nighttime event was 11min 58 sec.

[2)] if one scan scanned all quadrants, it is calculated as one scan for each quadrant→ total amount of scans now 1315 since some scans count several time

Table 1:

Date	Radar data available	larger data gaps	Scan mode (sec)	# of events in period	Allsky (NYA) available	MSP (Keograms) available	Super Darn available
16.01.2001	06:03:10-11:01:34	07:36:30-08:34:22	128	12	x	x	yes
17.01.2001	06:01:02-10:50:38	07:13:02-09:16:02	128	9	x	x	yes
18.01.2001	06:05:07-07:31:09		192	5	x	x	yes
19.01.2001	06:02:38-11:58:54	07:55:42-09:31:42	128	8	x	08:00 - 21:00	yes
20.01.2001	06:03:02-10:59:12	07:15:12-09:55:22	128	12	x	x	yes
25.01.2001	18:00:28-22:55:59		256	3	x	x	yes
15.12.2001	06:03:54-10:58:06	07:43:06-09:08:17	192	8	x	08:00 - 16:00	yes
16.12.2001	06:05:01-10:57:52		192	15	08:00 - 11:00	09:00 - 00:00	yes
17.12.2001	06:05:30-10:58:40	06:56:29-09:57:52	192	1	yes	yes	yes
18.12.2001	06:31:02-10:53:42	08:03:50-09:22:59	192	6	yes	yes	yes
19.12.2001	06:00:51-08:44:29		192	1	yes	yes	yes
20.12.2001	06:00:01-10:54:47	07:58:22-10:06:47	192	12	06:00 - 10:00	until 11:00	yes
21.12.2001	06:00:38-10:55:02		256	4	yes	X	yes
06.02.2002	16:01:10-22:57:30	16:56:35 - 17:36:54	256,gap192,	12	yes	18:00 - 00:00	yes
07.02.2002	17:12:24 - 22:59:36		192,21:00 256	6	yes	18:00 - 00:00	yes
08.02.2002	16:01:00 - 22:58:01		192	8	yes	yes	yes
09.02.2002	16:02:10 - 22:54:16		192, 18:00 256, 20:20 384	3	yes	yes	yes
15.12.2002	07:51:19 - 10:40:55		192	2	yes	x	yes

Event	Date of event	Start	Stopp	# images	Quadrant	Dir. of ion flow	Quality	Class	wideness	background	comment
1	16.01.2001	06:03	06 06	3	2	north-west flow	good	c.c.	medio	a little diffuse	north-west flow in a general south-east flow background
2	16.01.2001	06:19	06:26	4	2	south-east flow	good	c.c.	narrow	uniform	signature lying at the lower scan border
3	16.01.2001	08:49	08:51	2	3	north-east flow	ok	c.c.	narrow	a little diffuse	
4	16.01.2001	08.55	09.01	4	3	north-east flow	good	c.c.	narrow	a little diffuse	
5	16.01.2001	09:08	09.08	1	3	north-east flow	good	c.c.	narrow	a little diffuse	
6	16.01.2001	09:31	09:31	1	3	north-east flow	good	c.c.	narrow	a little diffuse	
7	16.01.2001	09:33	09:44	6	3	south-west flow	good	c.c.	medio	uniform	
8	16.01.2001	09:48	09:53	3	3	south-west flow	ok	c.c.	narrow	uniform	one scan lacking some data points
9	16.01.2001	09:57	10:01	3	3	south-west flow	ok	c.c.	narrow	a little diffuse	low ion velocity background
10	16.01.2001	10:07	10:14	4	3	north-east flow	good	c.c.	narrow	ok	best at 10:10, lying at the upper scan boundary, low ion velocity background
11	16.01.2001	10 18	10:20	2	3	north-east flow	ok	c.c.	narrow	uniform	
12	16.01.2001	10:22	10:31	5	3	north-east flow	good	c.c.	narrow	ok	best at 10:29-10 31, at the beginning not very high velocity
13	17.01.2001	06:19	06:26	4	1	north-east flow	poor	c.c.	narrow	diffuse	best at 6:26
14	17.01.2001	06:38	06:43	3	1	north-east flow	poor	c.c.	narrow	diffuse	not very high ion velocity
15	17.01.2001	06:51	07:00	5	1	north-east flow	ok	c.c.	medio	diffuse	best at 06:55-07:00
16	17.01.2001	07:10	07:13	2	1	north-east flow	good	c.c.	narrow	ok	poor data in next scan. direction of scan changed two frames later
17	17.01.2001	09:33	09:33	1	2	north-west flow	ok	c.c.	narrow	diffuse	
18	17.01.2001	09:50	09:59	5	2	north-west flow	ok	c.c.	narrow	diffuse	small "toung" of vi flow on upper outer scan
19	17.01.2001	10:08	10:14	4	2	north-west flow	poor	c.c.	narrow	diffuse	hard to see, low velocity
20	17.01.2001	10:18	10:22	3	2	south-east flow	poor	c.c.	narrow	diffuse	
21	17.01.2001	10:31	10:46	8	2	south-east flow	poor	c.c.	narrow	diffuse	
22	18.01.2001	06:17	06:17	1	1	north-east flow	good	c.c.	narrow	uniform	
23	18.01.2001	06:36	06:36	1	1	north-east flow	good	c.c.	narrow	uniform	
24	18.01.2001	06:43	06:43	1	1	north-east flow	good	c.c.	narrow	uniform	
25	18.01.2001	06:52	06:55	2	1	north-east flow	good	c.c	narrow	uniform	
26	18.01.2001	07:08	07:11	2	1	north-east flow	good	c.c.	narrow	uniform	
27	19.01.2001	06:11	06:21	6	1	north-east flow	good	c.c	narrow	diffuse	low ion velocity background
28	19.01.2001	06:23	06:28	3	1	south-west flow	poor	c.c.	narrow	diffuse	low ion velocity background
29	19.01.2001	06:58	07:00	2	1	south-west flow	poor	c.c	narrow	a little diffuse	best at 07:00
30	19.01.2001	10:01	10:03	2	2	south-east flow	poor	c.c.	narrow	diffuse	low velocity, narrow c.c. appearing often during period 10:01-11:45
31	19.01.2001	10:20	10:20	1	2	north-west flow	poor	c.c.	narrow	diffuse	low velocity
32	19.01.2001	10:35	10:37	2	2	south-east flow	poor	c.c.	narrow	diffuse	low velocity
33	19.01.2001	11:18	11:20	2	2	south-east flow	ok	c.c.	narrow	diffuse	low velocity c.c.
34	19.01.2001	11:35	11:43	5	2	south-east flow	ok	c.c.	narrow	diffuse	good at 11:43, low ion velocity
35	20.01.2001	06:04	06:17	7	1	north-east flow	good	c.c	medio	a little diffuse	06:04, 06:06, 06:13, 06:15 appears an other c.c. on the right scan border
36	20.01.2001	06:19	06:21	2	1	north-east flow	ok	c.c.	narrow	uniform	
37	20.01.2001	06:28	06:32	3	1	north-east flow	ok	c.c	narrow	a little diffuse	data gaps
38	20.01.2001	06:34	06:36	2	1	south-west flow	poor	c.c.	narrow	a little diffuse	best 06:36
39	20.01.2001	06:43	06:47	3	1	south-west flow	good	c.c.	narrow	uniform	c.c. at right scan border
40	20.01.2001	06:45	06:47	2	1	south-west flow	good	c.c	narrow	a little diffuse	c.c. in the middle of scan
41	20.01.2001	07:02	07:10	5	1	north-east flow	good	c.c.	narrow	a little diffuse	
42	20.01.2001	10:01	10:03	2	2	south-east flow	good	c.c.	narrow	uniform	c.c. lying at lower scan boundary/cutoff
43	20.01.2001	10:05	10:10	3	2	south-east flow	ok	spot	narrow	uniform	velocity spot

Event	Date of event	Start	Stopp	# images	Quadrant	Dir. of ion flow	Quality	Class	wideness	background	comment
44	20.01.2001	10:22	10:25	2	2	south-east flow	ok	c.c.	narrow	ok	low ion velocity c.c.
45	20.01.2001	10:29	10:33	3	2	south-east flow	poor	c.c	narrow	ok	low speed, two c.c.'s, one moving north, one appearing 10:31
46	20.01.2001	10:44	10:46	2	2	south-east flow	good	c.c	narrow	ok	low speed c.c
47	25.01.2001	18:10	18:27	5	4	north-west flow	good	spot	medio	uniform	low speed spot of reverse velocity
48	25.01.2001	22:09	22:26	5	4	north-west flow	good	spot	narrow	uniform	
49	25.01.2001	22:17	22:21	2	4	north-west flow	good	spot	narrow	uniform	
50	15.12.2001	06:13	06:23	4	1	north-east flow	good	c.c.	narrow	uniform	
51	15.12.2001	07:27	07:36	4	1	north-east flow	ok	c.c.	narrow	uniform	c.c. moving from south of svalbard north
52	15.12.2001	07:33	07:39	3	1	north-east flow	good	c.c.	narrow	uniform	c.c. appearing south of svalbard
53	15.12.2001	09:11	09:11	1	1	north-east flow	good	c.c.	narrow	ok	one c.c. over svalbard, another small one south of svalbard
54	15.12.2001	09:14	09:17	2	1	south-east flow	good	c.c.	narrow	uniform	c.c. on lower right scan boundary
55	15.12.2001	09:24	09:24	1	1	north-east flow	good	c.c.	narrow	uniform	
56	15.12.2001	09:28	09:28	1	3	north-east flow	ok	c.c.	narrow	uniform	
57	15.12.2001	10:10	10:54	6	3	south-east flow	good	c.c.	narrow	uniform	10:29-10:48 may look like an north-east c.c., best 10:51-10:54
58	16.12.2001	06:30	06:33	2	1	north-east flow	good	c.c.	medio	a little diffuse	
59	16.12.2001	06:40	06:40	1	1	south-west flow	ok	c.c.	medio	a little diffuse	bad data before and after
60	16.12.2001	06:46	06:46	1	1	north-east flow	poor	c.c.	narrow	a little diffuse	bad data before and after
61	16.12.2001	07:09	07:12	2	1	north-east flow	poor	c.c.	narrow	a little diffuse	
62	16.12.2001	07:31	07:37	3	1	north-east flow	poor	c.c.	narrow	a little diffuse	
63	16.12.2001	07:44	07:47	2	1	north-east flow	ok	c.c.	narrow	uniform	
64	16.12.2001	08:03	08:06	2	1	north-west flow	ok	c.c.	narrow	uniform	very interesting period with lots of c.c.'s until 09:27
65	16.12.2001	08:06	08:29	8	1	north-east flow	good	c.c.	narrow	uniform	
66	16.12.2001	08:20	08:23	2	2	north-west flow	ok	c.c.	narrow	uniform	
67	16.12.2001	08:32	08:52	7	1	north-east flow	good	c.c.	narrow	uniform	
68	16.12.2001	08:39	08:48	4	2	north-west flow	good	c.c.	narrow	uniform	
69	16.12.2001	08:55	09:27	11	1	north-east flow	good	c.c.	narrow	uniform	
70	16.12.2001	09:34	09:50	6	3	north-east flow	ok	c.c.	narrow	uniform	low velocity, best 09:44&09:47
71	16.12.2001	10:19	10:41	8	3	north-east flow	good	c.c.	narrow	uniform	very narrow & great at 10:25
72	16.12.2001	10:51	10:57	3	3	north-east flow	good	c.c.	narrow	uniform	unfortunately terminated by change in radar f.o.v
73	17.12.2001	10:17	10:17	1	3	north-east flow	ok	c.c.	narrow	uniform	
74	18.12.2001	06:43	06:47	2	1	north-east flow	good	c.c.	narrow	ok	best 6:43
75	18.12.2001	07:54	08:00	3	1	north-east flow	good	c.c	narrow	uniform	great at 08:00
76	18.12.2001	08:03	08:03	1	1	south-west flow	good	c.c.	narrow	uniform	2 shears, only one frame due to change of radar f.o.v., interesting change of conv.
77	18.12.2001	09:38	09:51	5	3	north-east flow	good	c.c	medio	uniform	
78	18.12.2001	09:54	10:10	5	3	north-west flow	good	c.c.	narrow	uniform	kjellmar et al., best 10:01-10:04
79	18.12.2001	10:07	10:23	6	3	north-east flow	good	c.c.	narrow	uniform	small c.c. developping in the last scan of previous event
80	19.12.2001	07:07	07:17	4	1	north-east flow	poor	c.c.	narrow	uniform	low velocity c.c.
81	20.12.2001	06:03	06:03	1	1	north-east flow	ok	c.c.	narrow	a little diffuse	
82	20.12.2001	06:06	06:06	1	1	north-east flow	poor	c.c.	medio	a little diffuse	
83	20.12.2001	06:12	06:12	1	1	north-east flow	ok	c.c.	narrow	ok	narrow c.c lying north of svalbard

84	20.12.2001	06:19	06:19	1	1	north-east flow	good	c.c.	narrow	a little diffuse	
Event	**Date of event**	**Start**	**Stopp**	**# images**	**Quadrant**	**Dir. of ion flow**	**Quality**	**Class**	**wideness**	**background**	**comment**
85	20.12.2001	06:44	06:47	2	1	north-east flow	poor	c.c.	narrow	diffuse	bad quality, not very clearly visible
86	20.12.2001	06:51	07:00	4	1	north-east flow	ok	spot	narrow	a little diffuse	spot
87	20.12.2001	07:07	07:10	2	1	north-east flow	poor	c.c.	narrow	a little diffuse	low ion velocity
88	20.12.2001	07:13	07:19	3	1	north-east flow	good	spot	narrow	uniform	
89	20.12.2001	07:42	07:42	1	1	north-east flow	good	c.c.	narrow	a little diffuse	
90	20.12.2001	10:13	10:22	4	3	north-east flow	ok	c.c.	narrow	ok	low ion velocity
91	20.12.2001	10:25	10:38	5	3	north-east flow	good	c.c.	narrow	uniform	shear, getting broader
92	20.12.2001	10:41	10:54	5	3	north-east flow	good	c.c.	narrow	uniform	best 10:51 & 10.54
93	21.12.2001	07:38	07:51	4	3	south-west flow	good	c.c.	narrow	a little diffuse	getting wider towards the end
94	21.12.2001	08:04	08:12	3	3	north-east flow	ok	c.c.	medio	a little diffuse	best 8:08
95	21.12.2001	08:55	09:25	8	3	south-west flow	good	c.c.	narrow	a little diffuse	
96	21.12.2001	09:29	09:34	2	3	north-east flow	ok	c.c.	narrow	a little diffuse	
97	06.02.2002	17:36	17:39	2	1	south-west flow	good	c.c.	medio	uniform	
98	06.02.2002	17:49	17:55	3	1	south-west flow	good	c.c.	medio	uniform	
99	06.02.2002	18:18	18:24	3	4	north-west flow	ok	c.c.	medio	uniform	
100	06.02.2002	18:43	18:46	2	1	south-east flow	ok	c.c.	medio	diffuse	low ion velocity background
101	06.02.2002	18:46	18:59	5	1	north-east flow	good	c.c.	medio	diffuse	low ion velocity background
102	06.02.2002	18:53	18:59	3	1	north-east flow	good	c.c.	narrow	ok	low ion velocity background
103	06.02.2002	20:16	20:22	3	1	north-east flow	good	c.c.	narrow	uniform	unfortunately data gap in one frame
104	06.02.2002	20:48	20:48	1	4	south-west flow	good	spot	medio	uniform	
105	06.02.2002	21:34	21:34	1	3	north-east flow	ok	c.c.	narrow	uniform	
106	06.02.2002	21:43	21:53	4	2	north-west flow	good	c.c.	narrow	uniform	low velocity
107	06.02.2002	22:22	22:22	1	3	south-east flow	good	spot	narrow	uniform	spot east of svalbard
108	06.02.2002	22:22	22:35	5	3	north-east flow	ok	spot	medio	diffuse	spot south of svalbard
109	07.02.2002	17:33	17:38	3	2	north-west flow	ok	c.c.	narrow	uniform	low velocity
110	07.02.2002	18:11	18:27	6	1	south-west flow	good	c.c.	narrow	uniform	
111	07.02.2002	20:31	20:31	1	1	north-east flow	good	spot	narrow	uniform	signature cut off by radar f.o.v
112	07.02.2002	20:38	20:47	4	1	north-east flow	good	c.c.	medio	uniform	
113	07.02.2002	20:57	21:04	3	2	north-west flow	good	c.c.	narrow	a little diffuse	at lower scan border
114	07.02.2002	22:21	22:29	3	4	north-west flow	ok	c.c.	narrow	a little diffuse	determined by bad data
115	08.02.2002	16:23	16:36	5	1	south-west flow	good	c.c.	medio	uniform	best 16:36, low ion velocity
116	08.02.2002	16:39	16:42	2	1	south-west flow	good	c.c.	narrow	uniform	low ion velocity
117	08.02.2002	16:55	17:14	7	4	south-west flow	ok	c.c.	medio	uniform	
118	08.02.2002	19:57	20:17	7	4	north-west flow	ok	c.c.	medio	a little diffuse	
119	08.02.2002	20:29	20:45	6	4	north-west flow	good	c.c.	narrow	uniform	medio velocity
120	08.02.2002	20:49	20:58	4	4	south-east flow	good	c.c.	narrow	a little diffuse	great 20:49-20:52
121	08.02.2002	21:41	21:45	2	3	north-east flow	ok	c.c.	medio	a little diffuse	best 21:41
122	08.02.2002	22:06	22:11	2	3	north-east flow	good	c.c.	narrow	a little diffuse	
123	09.02.2002	18:57	19:14	5	1	north-east flow	ok	c.c.	medio	a little diffuse	
124	09.02.2002	19:36	19:44	3	4	north-west flow	good	c.c.	narrow	uniform	terminated by bad data
125	09.02.2002	21:24	21:31	2	3	south-west flow	poor	c.c.	medio	a little diffuse	

126	15.12.2002	08:10	08:13	2	1	south-west flow	ok	c.c.	narrow	uniform
127	15.12.2002	10:21	10:21	1	1	south-west flow	ok	c.c.	narrow	a little diffuse

Event	Date of event	Start	Stopp	IMF Bz	IMF By	ne sig.
1	16.01.2001	06:03	06:06	>0	>0	n.o.
2	16.01.2001	06:19	06:26	<0	<0	n.o.
3	16.01.2001	08:49	08:51	<0	>0	gap
4	16.01.2001	08:55	09:01	<0	>0	enhanced - gap
5	16.01.2001	09:08	09:08	<0	>0	n.o.
6	16.01.2001	09:31	09:31	<0	>0	n.o.
7	16.01.2001	09:33	09:44	<0	<0	hard to see, gap in last scan
8	16.01.2001	09:48	09:53	<0	<0	n.o.
9	16.01.2001	09:57	10:01	<0	<0	n.o.
10	16.01.2001	10:07	10:14	<0	<0	n.o.
11	16.01.2001	10:18	10:20	<0	>0	gap
12	16.01.2001	10:22	10:31	<0	>0	gap
13	17.01.2001	06:19	06:26	>0	>0	maybe enhanced
14	17.01.2001	06:38	06:43	>0	>0	n.o.
15	17.01.2001	06:51	07:00	>0	>0	n.o.
16	17.01.2001	07:10	07:13	>0	>0	n.o.
17	17.01.2001	09:33	09:33	>0	>0	gap
18	17.01.2001	09:50	09:59	>0	>0	enhanced
19	17.01.2001	10:08	10:14	>0	>0	enhanced
20	17.01.2001	10:18	10:22	>0	>0	enhanced
21	17.01.2001	10:31	10:46	>0	>0	enhanced
22	18.01.2001	06:17	06:17	<0	>0	gap
23	18.01.2001	06:36	06:36	>0	>0	enhanced
24	18.01.2001	06:43	06:43	<0	>0	enhanced
25	18.01.2001	06:52	06:55	<0	>0	enhanced
26	18.01.2001	07:08	07:11	<0	>0	enhanced

27	19.01.2001	06:11	06:21	>0	>0	n.o.
28	19.01.2001	06:23	06:28		>0	n.o.
29	19.01.2001	06:58	07:00	<0	>0	n.o.
30	19.01.2001	10:01	10:03	>0	>0	gap
31	19.01.2001	10:20	10:20	>0	>0	enhanced
32	19.01.2001	10:35	10:37	>0	>0	enhanced
33	19.01.2001	11:18	11:20	<0	>0	enhanced
34	19.01.2001	11:35	11:43	<0	>0	n.o.
35	20.01.2001	06:04	06:17	<0	<0	enhanced
36	20.01.2001	06:19	06:21	<0	<0	n.o.
37	20.01.2001	06:28	06:32	<0	<0	enhanced/patch
38	20.01.2001	06:34	06:36	<0	<0	patch 6:38-6:49
39	20.01.2001	06:43	06:47	<0	<0	""
40	20.01.2001	06:45	06:47	<0	<0	enhanced
41	20.01.2001	07:02	07:10	<0	<0	n.o./gap
42	20.01.2001	10:01	10:03	>0	>0	n.o.
43	20.01.2001	10:05	10:10	>0	>0	n.o./gap
Event	**Date of event**	**Start**	**Stopp**	**IMF Bz**	**IMF By**	**ne sig.**
44	20.01.2001	10:22	10:25	>0	>0	n.o.
45	20.01.2001	10:29	10:33	>0	>0	n.o.
46	20.01.2001	10:44	10:46	>0	>0	enhanced
47	25.01.2001	18:10	18:27	<0	>0	n.o.
48	25.01.2001	22:09	22:26	<0	<0	n.o.
49	25.01.2001	22:17	22:21	<0	<0	n.o.
50	15.12.2001	06:13	06:23	>0	>0	n.o.
51	15.12.2001	07:27	07:36	<0	>0	n.o.
52	15.12.2001	07:33	07:39	<0	>0	n.o.

53	15.12.2001	09:11	09:11	<0	>0	enhanced
54	15.12.2001	09:14	09:17	fluctuates	>0	enhanced
55	15.12.2001	09:24	09:24	fluctuates	>0	n.o.
56	15.12.2001	09:28	09:28	>0	>0	n.o.
57	15.12.2001	10:10	10:54	>0	>0	n.o., but interesting spot south
58	16.12.2001	06:30	06:33	<0	>0	gap
59	16.12.2001	06:40	06:40	<0	>0	enhanced
60	16.12.2001	06:46	06:46	<0	>0	n.o./enhanced
61	16.12.2001	07:09	07:12	>0	>0	gap
62	16.12.2001	07:31	07:37	>0	>0	enhanced
63	16.12.2001	07:44	07:47	>0	>0	n.o.
64	16.12.2001	08:03	08:06	>0	>0	enhanced
65	16.12.2001	08:06	08:29	>0	>0	enhanced
66	16.12.2001	08:20	08:23	>0	>0	gap?
67	16.12.2001	08:32	08:52	>0	>0	enhanced
68	16.12.2001	08:39	08:48	>0	>0	enhanced
69	16.12.2001	08:55	09:27	>0	>0	enhanced
70	16.12.2001	09:34	09:50	>0	>0	n.o.
71	16.12.2001	10:19	10:41	>0	>0	enhanced
72	16.12.2001	10:51	10:57	>0	>0	enhanced, not much
73	17.12.2001	10:17	10:17	>0	>0	enhanced, precipitation
74	18.12.2001	06:43	06:47	<0	>0	n.o.
75	18.12.2001	07:54	08:00	<0	>0	enhanced
76	18.12.2001	08:03	08:03	<0	>0	n.o.
77	18.12.2001	09:38	09:51	<0	>0	n.o.
78	18.12.2001	09:54	10:10	<0	>0	gap, not very clear
79	18.12.2001	10:07	10:23	<0	>0	n.o.

80	19.12.2001	07:07	07:17	<0	>0	n.o.
81	20.12.2001	06:03	06:03	<0	>0	gap
82	20.12.2001	06:06	06:06	>0	>0	gap
83	20.12.2001	06:12	06:12	<0	>0	enhanced, precipitation
84	20.12.2001	06:19	06:19	<0	>0	enhanced, precipitation
Event	**Date of event**	**Start**	**Stopp**	**IMF Bz**	**IMF By**	**ne sig.**
85	20.12.2001	06:44	06:47	>0	>0	enhanced, precipitation
86	20.12.2001	06:51	07:00	<0	>0	enhanced, weak, precipitation 6:54
87	20.12.2001	07:07	07:10	>0	>0	n.o.
88	20.12.2001	07:13	07:19	>0	>0	enhanced, weak
89	20.12.2001	07:42	07:42	<0	>0	gap
90	20.12.2001	10:13	10:22	<0	>0	gap
91	20.12.2001	10:25	10:38	<0	>0	enhanced, clear
92	20.12.2001	10:41	10:54	<0	>0	enhanced, clear
93	21.12.2001	07:38	07:51	<0	>0	enhanced, weak?
94	21.12.2001	08:04	08:12	>0	>0	gap?
95	21.12.2001	08:55	09:25	<0	>0	n.o.
96	21.12.2001	09:29	09:34	<0	>0	n.o.
97	06.02.2002	17:36	17:39	>0	>0	n.o.
98	06.02.2002	17:49	17:55	>0	>0	n.o.
99	06.02.2002	18:18	18:24	>0	>0	n.o.
100	06.02.2002	18:43	18:46	<0	>0	n.o.
101	06.02.2002	18:46	18:59	<0	>0	n.o.
102	06.02.2002	18:53	18:59	>0	>0	n.o.
103	06.02.2002	20:16	20:22	<0	>0	n.o.
104	06.02.2002	20:48	20:48	>0	>0	n.o.

105	06.02.2002	21:34	21:34	<0	>0	n.o.
106	06.02.2002	21:43	21:53	>0	>0	enhanced
107	06.02.2002	22:22	22:22	<0	>0	n.o.
108	06.02.2002	22:22	22:35	<0	<0	gap
109	07.02.2002	17:33	17:38	>0	<0	n.o.
110	07.02.2002	18:11	18:27	>0	<0	n.o.
111	07.02.2002	20:31	20:31	<0	>0	n.o.
112	07.02.2002	20:38	20:47	<0	>0	n.o.
113	07.02.2002	20:57	21:04	<0	<0	n.o.
114	07.02.2002	22:21	22:29	>0	<0	n.o.
115	08.02.2002	16:23	16:36	<0	>0(<0)	n.o., gap
116	08.02.2002	16:39	16:42	<0	>0	enhanced, precipitation
117	08.02.2002	16:55	17:14	<0	>0	enhanced, precipitation!
118	08.02.2002	19:57	20:17	fluctuates	>0	n.o.
119	08.02.2002	20:29	20:45	fluctuates	>0	n.o.
120	08.02.2002	20:49	20:58	fluctuates	>0	n.o.
121	08.02.2002	21:41	21:45	<0	>0	n.o.
122	08.02.2002	22:06	22:11	<0	>0	gap
123	09.02.2002	18:57	19:14	>0	>0	n.o., precipitation
124	09.02.2002	19:36	19:44	>0	>0	n.o., precipitation
125	09.02.2002	21:24	21:31	<0	<0	n.o.
126	15.12.2002	08:10	08:13	>0	<0	enhanced
127	15.12.2002	10:21	10:21	<0	<0	enhanced

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